# Vitamin D Status of Submariners During Patrol


by

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## SUMMARY PAGE

### THE PROBLEM

To determine if vitamin supplementation will prevent the decline in vitamin D levels found during prolonged submarine patrols.

### THE FINDINGS

Vitamin D (ergocalciferol) supplementation maintained the pre-patrol levels of circulating vitamin D (25-OH-D) in submariners while the levels declined in a group taking only a placebo.

### APPLICATION

These findings suggest that vitamin supplementation should be strongly recommended for all submariners during patrol.

### ADMINISTRATIVE INFORMATION

This invetigation was conducted as part of Naval Medical Research and Development Command Work Unit 61152N MR000.01.01-5088, "Behavioral and electrophysiological indices of environmental hazards in submariners." It was submitted for review on 8 November 1988, approved for publication on 31 January 1989, and designated as NSMRL Report # 1129.

## ABSTRACT

The circulating vitamin D (25-OH-D) levels were measured in 22 submariners before, during and after a two month patrol. Eleven subjects received a multivitamin-mineral supplement that contained 10.0 mg of ergocalciferol while the other 11 received a placebo. Vitamin D levels decreased during the patrol for both groups but the decline was significant only for the placebo group. Post patrol blood levels were higher than prepatrol levels due to the change in season and the higher levels of ultraviolet radiation in the environment.

Vitamin deficiencies have been reported during submarine patrols. Specifically vitamin C[1] and vitamin B-6[2] levels are decreased during prolonged patrols. There is reason to believe that vitamin D levels may also be reduced, as there is little or no exposure to natural sunlight during a patrol and the powdered dairy products available to the crew were not supplemented with vitamin D at the time this study was undertaken. Luria[3] studied vitamin D levels in submariners but the study group was split into two groups that began their patrols at different times of the year making the interpretation of results difficult.

The importance of vitamin D to health and particularly to calcium metabolism has been established by various investigators[4]. Prolonged deprivation of vitamin D can lead to rickets in children and osteomalacia in adults[5]. Davis and Morris[6,7] have reported that the calcium metabolism of submariners is deficient, and they attribute this alteration to the lack of exposure to UV radiation[8].

Typically, a submarine is lighted by standard "cool white" fluorescent tubes which emit very little of the ultraviolet radiation (UV) that is essential for vitamin D synthesis in the skin. This lack of UV exposure is complicated by dietary changes. After thirty days at sea, fresh fruits and vegetables are no longer available. Fresh dairy products are replaced by powdered substitutes.

During a patrol, submariners are also exposed to both psychological and physical stresses. They are separated from their families, confined in a limited area, and the length of their day is shifted from 24 to 18 hours. The purpose of this study was to examine the levels of circulating vitamin $D_3$ (25-hyroxiyvitamin $D_3$) in submariners deprived of natural sunlight for approximately two months and to determine if a vitamin supplement would ameliorate any defici4encies that might develop over the course of the patrol.

## Subjects

Twenty-two male volunteers representing approximately one-fourth the crew, aged 18-35 years, were recruited from the crew of an American fleet ballistic nuclear-powered submarine about to go on a 2-month deployment. Each subject was given a complete physical examination, and informed written consent was obtained before acceptance into the study. All subjects had previously been on prolonged submarine patrols. The study was approved by the Human Studies Committee of the Naval Submarine Base before it was initiated.

## Procedure

After acceptance into the study, the men were instructed to

cease taking any nutritional supplements for at least 1 month before the initial blood samples were obtained. Of the 22 volunteers, only 6 routinely took nutritional supplements when not on patrol, and an additional 2 took such supplements only when on patrol. After the 1-month period of no supplementation, fasting venous blood samples were obtained. This is referred to as the prepatrol sample.

At each sampling period, a 7ml sample of blood was drawn from the antecubital vein. The blood was immediately centrifuged and 2 cc of serum was frozen at -20°C for subsequent analysis. All samples were collected after an 8-hour fast.

Blood samples were collected near midpatrol, immediately before surfacing at the end of the patrol (~ 1 month after the midpatrol sample and 2 months after the patrol began) and 30 days after the crew had returned to the base. Both groups of subjects were instructed not to take any nutritional supplements after completion of the patrol until after the last blood sample was obtained.

On the first day of the patrol, each subject was assigned in a double-blind manner to receive either a daily multivitamin-mineral supplement or a non-nutritional placebo. The Commanding Officer of the submarine had a copy of the coding sequence in his safe in case the code was needed to be broken while at sea. Twelve men received the supplement and twelve received the placebo. The supplements provided 10.0 mg of ergocalciferol, an amount estimated to raise the total daily intake of the subjects to the current RDA for vitamin D. One bottle of supplement or placebo was taken on a 24-hour cycle rather than on the basis of the standard 18-hour day. A log of medical health-related problems was also kept for each subject throughout the patrol.

In this preliminary study, intakes of foods by the subjects were not assessed because of possible interference in the work requirements of the subjects.

## Statistical Analyses

A two way analysis of covariance was performed with groups (supplemented or placebo) and sampling period (mid, end, and post) as the independent class variables. Prepatrol 25 OH-D level was the covariate.

## RESULTS

Figure 1 presents the data for each time interval for each group. The placebo group showed a 38% drop in circulating 25 OH-D at the mid-patrol interval and a 40% drop by the end of the patrol. The supplemented group showed a 17% decrease in blood levels at mid-patrol and a 3% decrease at the end of the patrol.

The Merck Manual identifies 25 to 40 ng/ml as the reported values for healthy subjects[10]. In both groups the vitamin $D^3$ levels post patrol were above all patrol values and also above the prepatrol values.

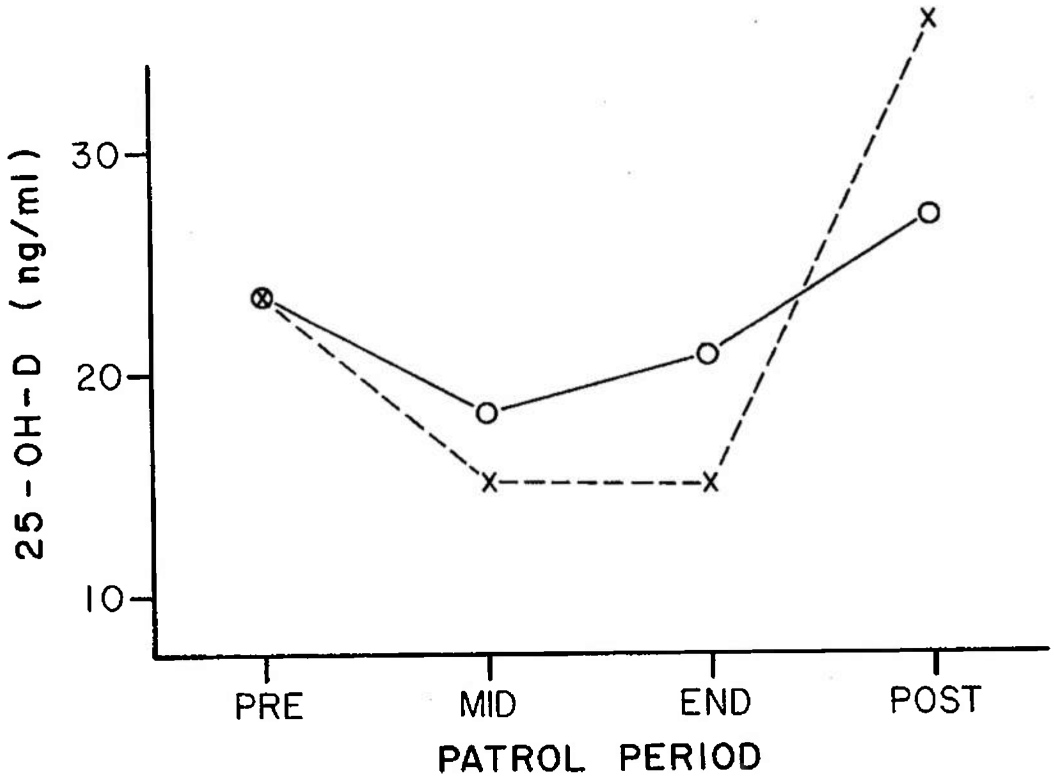


Figure 1. The 25 OH-D (ng/ml) levels for the supplemented (o-o) and placebo (x-x) groups for each patrol period.

For the nonsupplemented group, all eleven of the subjects showed a decline in vitamin D levels from the prepatrol to the mid-patrol measure, and ten of the eleven from prepatrol to the end of the patrol. Both these declines are significant on a sign test at the $p < .01$ level.

In the supplemented group, eight of the eleven subjects showed a decrease at mid-patrol, and only five showed a decline over prepatrol at the end of the patrol. Neither of these differences were significant on the sign test.

The difference between the supplemented and the placebo group in 25 OH-D levels was significant (Hotellings F=21.02, df=3,83, p<.001). The difference in vitamin D levels across each of the

three patrol sampling periods was also significant (df=1,85, for each of the three comparisons - mid-patrol F=7.63, p=.007; end patrol F=32.73, p=.001; post-patrol F=7.03, P=.01).

## DISCUSSION

Vitamin D is required for both phosphorous homeostasis and calcium absorption in the intestine. At the time this study was performed, the powdered milk and powdered milkshake products available on the submarine during patrol were not supplemented with vitamin D1. The lack of a significant dietary source of vitamin D led to substantial decreases in circulating vitamin D in the placebo group and smaller reductions in the supplemented group. This was compounded by no exposure to natural sunlight and the availability only of environmental light that was deficient in ultraviolet radiation (UV).

The effect of environmental UV on vitamin D levels is further shown by the increase in post-patrol vitamin D levels over the prepatrol baseline measures. Prepatrol samples were taken in November in Groton, CT. At this time of year the sun is approximately 27 degrees above the horizon while in June when the post-patrol samples were taken, it is approximately 70 degrees above the horizon and there are four more hours of sunlight. In November the sun's rays pass through the atmosphere at a more oblique angle and there is greater reduction in the ultraviolet by its absorption by ozone and greater light scattering than there is in June. As a result there is less synthesis of vitamin D by the skin in November than in June[4].

We have no explanation for the difference in vitamin D levels between the groups at the post-patrol intervgal other than possible differences in UV exposure and diet.

Davies[8] has reported that significant hypovitaminosis D occurs after six weeks of deprivation of sunlight. Luria[3] has shown that the use of full spectrum lighting during a patrol does not prevent this decline in blood levels of circulating 25-OH-D during a prolonged patrol. Our data support the finding of decreased vitamin D levels occurring by four weeks into the patrol (the mid-patrol values). Prior to deployment the crew spent approximately three weeks in a "refit" period during which they worked, ate, and lived on the submarine. Virtually all of the daylight hours were spent inside the submarine. The lack of UV exposure during the refit period may have contributed to the drop in vitamin D found at the mid-patrol interval.

This hypovitaminosis, found in normal healthy men, causes

"inadequate intestinal absorption of calcium and increasingly negative calcium balance"[8]. We do not know the long term clinical effects of this degree of hypovitaminosis. It appears that no published research has addressed this question. In severe vitamin D deficiencies in adults osteomalacia results with attendant softening of the bones. This softening increases the likelihood of fractures and shows up radiographically as decreased bone density and widening of the trabecular spaces and pseudofractures. The time course of the development of these changes is not documented. These areas of lutency remain for a considerable time after treatment.[11]

In this study supplementation was effective in ameliorating most of the reduction in vitamin $D_3$ found in the non-supplemented group. This occurred even in the absence of full spectrum lighting. Previous research in this and other laboratories has reported deficiencies in vitamin C and in B-6 in submariners during patrol. We do not know the long term consequences of these periodic deficiencies in vitamins. In view of the information that is beginning to accumulate, and in the absence of further research, it seems prudent to recommend that all submariners receive vitamin supplementation while on patrol.

## ACKNOWLEDGMENTS

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## DISCLAIMER

Naval Medical Research and Development Command, Navy Department, Research Work Unit 61152N - MR000.01.01-5088. The views expressed in this article are those of the authors an do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government.

## REFERENCES


1. Gilman, S. (1980) Vitamin C status of submariners. Naval Submarine Medical Research Laboratory Report #933.

2. Reynolds, R. D., Styer, D. J., & Schlichting, C. L. (1988) Decreased vitamin B-6 status of submariners during prolonged patrol. American Journal of Clinical Nutrition, 47, 463-469.

3. Luria, S. M. (1987) Effects of full spectrum lighting in submarines. Naval Submarine Medical Research Laboratory Report #1092.

4. Wurtman, R. J., Baum, M. J., & Potts, J. T., Jr. The medical and biological effects of light. Ann. N.Y. Acad. Sci. Vol 453.

5. Loomis, W. F. (1970) Rickets. Scientific American, 223, 76-91.

6. Davis, D. M., & Morris, J. E. W. (1974) Urinary excretion of calcium, magnesium and phosphorous in submariners. INM Report 28.74. Alverstoke, Gosport, England: Institute of Naval Medicine.

7. Davis, D. M., & Morris, J. E. W. (1979) Carbon dioxide and vitamin D effects of calcium metabolism in nuclear submariners: A review. Undersea Biomedical Research Supplement, S71-S80.

8. Davies, D. M. Calcium metabolism in healthy men deprived of sunlight. In R. J. Wurtman, M. J. Baum, & J. T. Potts, Jr. (Eds). The medical and biological effects of light. Ann. N.Y. Acad. Sci. Vol. 453, p. 21-27.

9. Kroop, A. D., & Shiller, W. R. (1968) Personal habits and diet in relation to periodontal health and oral hygiene status in submariners. Naval Submarine Medical Research Laboratory Report #528.

10. Berkow, R. (Ed.) (1982) The Merck Manual. Merck, Sharp & Dohme Research Laboratories, Rahway, MJ.

11. Goodhart, R. S., & Shils, M. E. (1978) Modern Nutrition in Health and Disease Dietotherapy. Lea & Febiger, Philadelphia.

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